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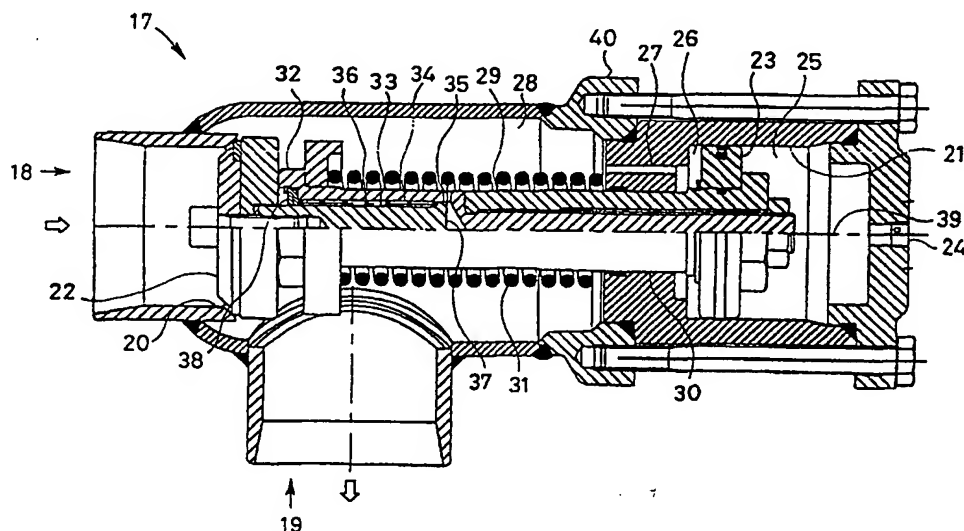
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(54) Title: A METHOD OF OPERATING A REFRIGERATION SYSTEM AND A CONTROL VALVE



## (57) Abstract

A control valve (17) comprises a valve housing (40) defining a valve seat (20) together with a valve cone (22) guided to be movable whereby to control passage of fluid from the valve inlet to the valve outlet. A valve piston (23) may force the valve cone toward sealing engagement with the valve seat. The valve cone is displaceable relative to the valve piston. The control valve may be used in a compressor driven refrigeration system as a check valve in the oil separator discharge line, an advantage being that it controls the pressure, checks any backflow, and leaves normal flow unthrottled.

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A Method of Operating a Refrigeration System and a Control Valve

5 This invention relates to a method of operating a compressor driven refrigeration system. The invention further relates to a control valve.

10 A compressor driven refrigeration system generally employs a fluid refrigerant conveyed in a closed loop adapted for taking the refrigerant through various pieces of equipment where it is subjected to changes of state and changes of temperature whereby thermal units may be moved from one place to another. Generally, the refrigerant will on one pass around the loop, in succession meet a compressor where  
15 gaseous refrigerant is compressed, a condenser where the refrigerant is condensed into liquid at substantially constant pressure and under dissipation of heat into the surroundings, an expansion valve where the pressure of the liquid refrigerant is relieved, and an evaporator where the  
20 liquid evaporates at substantially constant pressure while absorbing heat from the surroundings and from where the refrigerant returns to the compressor. The components mentioned are connected by sealed conduits for containing the refrigerant and the system may also incorporate check valves,  
25 control valves, shut-off valves, and other equipment as is convenient for controlling the operation, permitting maintenance etc.

30 Various types of compressors may be employed depending on functional requirements. For many applications screw compressors are preferred.

35 The screw compressor requires the injection of oil which serves the purposes of lubricating the compressor, sealing internal clearances, and cooling the screw compressor. The oil inevitably becomes mixed with the refrigerant to be carried away mainly as fine droplets carried in the flow of

gaseous refrigerant. As circulation of oil together with the refrigerant in other parts of the refrigerant loop generally is degrading to the performance, the compressed mixture of refrigerant and oil is taken to an oil separator from which  
5 refrigerant and oil are taken out separately. The oil is recycled in a separate oil loop to be reintroduced to the compressor. The oil loop may comprise a separate oil pump.

It is common practice to include in the refrigerant loop a  
10 discharge check valve downstream from the oil separator. The discharge check valve serves the purpose of preventing refrigerant from flowing backwards during intervals when the compressor is temporarily stopped. Backflow of refrigerant into the oil separator is disadvantageous as the refrigerant  
15 might condense in the oil separator which has the capacity of holding a substantial amount of liquid. The check valve, however, generally employs some type of spring necessary to effect a positive closing pressure but with the consequence of causing a pressure drop to the normal flow, which pressure  
20 drop represents a loss of energy. Another disadvantage to many types of check valves is an inherent propensity to unstable function on gas flows, meaning that the pressure drop fluctuates and that the valve cone is likely to rattle or oscillate erratically.

25 US patent 5 134 856 contains a suggestion to replace the discharge check valve by a control valve to be controlled by the difference between the pressures on the compressor suction side and the control valve discharge side. The  
30 control valve is to be tuned to open only when the pressure in the control valve discharge line exceeds the compressor suction line pressure by a difference of at least 2 Bars. A pressure differential of this scale is sufficient to drive oil around in the oil loop to keep the compressor oiled. As  
35 the screw compressor is capable of starting up and running for some time, building up some pressure, without lubrica-

tion, it may, provided the oil separator is not too large, be possible to dispense with the oil pump altogether.

5 However, in case refrigerant might have condensed in the oil separator discharge line, it may cause a considerable pressure here, which during a run-up phase could exceed that in the oil separator with the consequence that there might be circumstances where the control valve would open to allow refrigerant to flow back into the oil separator.

10 The invention provides a method as recited in claim 1.

15 By this method discharge of the refrigerant from the oil separator is blocked on start-up of the compressor after a period of stand-still in order that the compressor may quickly build up a pressure which is sufficient for driving oil from the oil separator back in the oil return line to feed the compressor as necessary. Once the predetermined level of overpressure has been attained, the control valve is inclined to open up but it will, however, only do so if also the condition that the pressure at the valve outlet does not exceed the pressure at the valve inlet is satisfied.

25 This method avoids accidental backflow of condensed refrigerant into the oil separator. If both conditions are satisfied and there is a positive pressure differential from the valve inlet to the valve outlet, the control valve will gradually open, throttling initially the throughflow so as to maintain at all times the preferable pressure in the oil separator while gradually reducing the pressure drop across the valve as the pressure in the valve discharge line gradually builds up. As the discharge line pressure gradually builds up, the valve will reach a state where it is fully open so as not to cause any significant pressure drop, which state is reached well before the operating pressure expected during normal service has been attained.

The control valve is according to the invention, effectively connected to sense the difference of pressures between a point in fluid communication with the compressor outlet and a point in fluid communication with the compressor inlet. The predetermined threshold level of pressure is established depending on the circumstances to a level where a satisfactory rate of oil feed is ensured. The control valve may be connected to points close to the compressor inlet and outlet or it may be connected to other points in the refrigerant loop where the pressure difference is sensed across a section of the loop including the compressor together with other components, e.g. the oil separator and possible check valves or others. In the latter case, the threshold level of pressure defined by the valve may have to be modified to take into account the pressure drop in other components as well as in sections of the connecting pipes so as to ensure the required feed-back of oil.

The invention further provides a control valve as recited in claim 5.

This valve includes a valve return spring biasing the valve cone towards closed position and a control valve piston sliding in a control valve cylinder capable of lifting the valve cone against the force of the return spring and tuned to initiate lifting when the difference between the pressure on the valve inlet side exceeds the pressure in the valve cylinder by a predetermined threshold level. The valve return spring is fully compressed in order not to throttle through-flow when this threshold level is exceeded by a substantial amount, selected however to be below the pressure attained during regular service.

In the new valve, however, the valve cone is not rigidly connected to the valve piston rod but axially movable relative to the valve piston rod. The axial motion of the valve cone is limited at one end by the valve seat engaging

the valve cone and at the opposite end by a rearward face of the valve cone engaging a front face of the piston rod. Between the valve stem and the piston rod, cone lifting means serve the purpose of biasing the valve cone to rest against the front face of the piston rod and thus to follow the movements of the piston rod. This design permits the valve cone to remain in sealing engagement with the valve seat, regardless of the displacement of the piston rod as long as the pressure differential across the valve cone prevails over the force of the cone lifting means.

The practical implementation of the cone lifting means may take different forms. In one form the cone may be displaceable relative to the valve piston rod, the differential pressure across the cone providing the lifting force. In this form the cone itself serves as cone lifting means. In a second form the force of gravity acting on the valve cone is utilized to provide the lifting force. This requires that the orientation of the valve is suitably controlled taking into account the masses involved. In a third form a cone lifting spring is arranged between the valve cone and the valve piston rod, the spring providing a force biasing the valve cone towards abutment against the valve piston rod. In a fourth form the valve piston rod features an axial bore communicating the valve control pressure to a cylinder arranged internally of the valve piston rod, in which cylinder the valve cone serves as the piston.

The cone lifting spring is sized so that the valve cone will stay in sealing engagement with the valve seat, provided the pressure on the valve outlet side exceeds the pressure on the valve inlet side by a small amount, e.g. 0.05 Bars depending on the orientation of the valve.

Once the valve cone has moved away from the engagement with the valve seat, obviously the pressure differential across the valve cone will vanish and the valve cone will move

together with the valve piston as a normal control valve. During normal operation, the pressure differential across the compressor will exceed the threshold level by a substantial amount and the valve will be fully opened with no rattling parts and with no appreciable pressure drop.

According to a preferred embodiment the cone lifting spring is adapted to apply a lifting force which is sufficient to ensure reliable lifting of the valve cone against forces due to adherence in the valve seat, friction and gravity regardless of the orientation of the control valve. This embodiment has the advantage that the same valve may be used in different system designs where the valve may be installed in different orientations.

The valve according to the invention may be implemented in a compact and comparatively simple design permitting cost effective manufacture and it needs basically only to be inserted in the discharge line from the oil separator and provided with a control line permitting it to sense the pressure at the compressor inlet side.

Further features and advantages of the invention will appear from the appended description of preferred embodiments given under reference to the drawings, wherein

Fig. 1 shows a valve according to a first embodiment of the invention in closed state and in longitudinal and partial section,

Fig. 2 a valve according to a second embodiment of the invention in a view similar to fig. 1,

Fig. 3 a system diagram of a first version of a refrigeration system where a valve according to the first embodiment of the invention is used,



Fig. 4 a system diagram of a second version of a refrigeration system where a valve according to the first embodiment of the invention is used,

5 Fig. 5 a system diagram of a third version of a refrigeration system where a valve according to the second embodiment of the invention is used,

10 Fig. 6 the valve of fig. 1 in a state with the piston lifted while the cone sealingly engages the seat,

Fig. 7 the valve of fig. 1 in an opened state, and

15 Fig. 8 a valve according to a third embodiment of the invention in a view similar to figure 6.

20 The figures are schematic and not necessarily to scale and illustrate only those parts which are essential in order to enable those skilled in the art to understand and practice the invention, other parts such as may readily be suggested by those skilled in the art being omitted from the drawings for the sake of clarity. Throughout the drawings identical references have been used to designate identical or similar  
25 features.

Reference is first made to fig. 1 illustrating a valve according to a first embodiment of the invention in longitudinal section. Fig. 1 shows the valve 17 comprising valve  
30 housing 40 defining valve inlet 18, valve seat 20 and valve outlet 19 and supporting various other parts. Valve cone 22 may, as illustrated in fig. 1, sealingly engage valve seat 20 thereby blocking passage of fluid from the valve inlet 18 into valve chamber 28 which is in fluid communication with  
35 the valve outlet 19.

Fig. 1 further illustrates the valve cylinder 21 sealingly and slideably receiving valve piston 23 solidly connected with valve stem 29 which projects along the axis 39 of the valve cylinder which coincides in the preferred embodiment with the axis of the valve seat 20. The valve stem is on the end projecting towards the valve seat provided with annular valve stem flange 32 which serves as the left hand abutment to valve return spring 31 coiled around the valve stem while a solid part of the valve housing 40 proximal to valve bore 30 serves as the right hand abutment to the valve return spring.

Rather than being rigidly connected to the valve stem, the valve cone is slideably guided by the valve stem, the valve cone being rigidly connected with valve cone shank 33 which is slideably received in a countersunk axial bore 34 in the valve stem. This permits axial displacement of the valve cone relative to the valve stem. In the position illustrated in fig. 1, the valve stem is displaced to the leftmost position, where it is held by the valve return spring applying a force to valve stem flange 32 which transfers this pressure through abutting surfaces to the valve cone 22 which is firmly pressed into a sealing engagement with the valve seat 20.

A cone lifting spring 36 is arranged on a part of the valve cone shank 33 with reduced section, the shank head 37 providing an annular ledge forming one abutment for the cone lifting spring, whereas the opposite end of the spring is compressed by retainer ring 38 solidly connected with valve stem flange 32. The volume enclosed inside the countersunk bore 34 and trapped by the valve cone shank 33 is relieved to the immediate surroundings through valve stem bleed hole 35 in order to facilitate sliding of the valve cone shank.

The volume enclosed in the valve cylinder 21 is divided by the valve piston 23 into upper volume 25 to the right hand side of the piston in the figure and lower volume 26 to the

other side of the piston. The valve cylinder also comprises an end port 24 shown to the right hand side in figure 1 in fluid communication with the upper volume and adapted in a manner not shown for fitting a fluid communication line. The lower volume 26 is relieved by bleed hole 27 to the valve chamber 28.

The function of the valve may be summarized as follows: The valve piston is subjected to the net force resulting from the difference among the pressures in the respective volumes, the lower volume being connected with the valve chamber 28, which is in turn connected with the valve outlet 19 and the upper volume being connected with the valve cylinder end port 24. The valve return spring biases the valve cone towards sealing engagement with the valve seat, the valve return spring being preferably designed to apply a force sufficient to keep the valve closed until the pressure differential between the valve inlet and the valve outlet attains a predetermined value, e.g. 2 Bars.

Since the cross sectional area of the valve cylinder is generally equivalent to the cross sectional area defined by the valve seat, a pressure differential across the valve piston generally similar to that between the cylinder end port and the valve outlet will be sufficient to overcome the force applied by the valve return spring thereby displacing the valve stem towards the right in fig. 1 relieving the closing force which had held the valve cone to the valve seat. The valve spring is gradually compressed by increasing pressure differential, the valve return spring, according to the preferred embodiment, being designed to yield to a state of maximum compression at a pressure differential of about 2.5 Bars.

As the valve stem moves towards the right, a valve cone lifting spring 36 applies a force to the valve cone shank tending to lift the valve cone off the seat. The lifting

spring is, however, designed for applying only a small force which may easily be overcome by any substantial back pressure on the valve, i.e. a pressure at the valve outlet exceeding the pressure at the valve inlet. In the preferred embodiment  
5 a pressure differential of 0.05 Bars is sufficient to hold the valve cone tightly in its seat regardless of the position of the valve stem.

Should the back pressure, however, drop below this value in  
10 a situation where the valve stem had moved at least partially to the right, the valve cone will lift on the biasing force of the lifting spring so as to permit partial or complete equalization of the pressures between valve inlet and valve outlet. Thus, there are conditions in which two stable states  
15 of the valve cone are possible, only past history deciding which one is taken: A closed state as illustrated in fig. 6 where the valve cone is held sealingly in the seat by a substantial back pressure or an open state as illustrated in fig. 7 in which the valve cone is lifted as much as the  
20 piston is displaced, in principle permitting flow in either direction.

Reference is now made to fig. 2 for a description of a second embodiment of the valve according to the invention. The  
25 greater part of the components of the valve 50 in the second embodiment are similar to those of the first embodiment, essentially with the exception that the valve cylinder lower volume 26 is communicated to a side port 51 adapted in a manner not shown for the fitting of a fluid communication  
30 line while the valve cylinder bleed hole 27 of the first embodiment is omitted in the second embodiment. In the valve 50, according to the second embodiment, the piston is effectively subjected to the force caused by the difference in pressures among the valve cylinder end port 24 and the  
35 valve cylinder side port 51. All other functions are essentially similar to the valve of the first embodiment, therefore reference may be made to the above description.

Reference is now made to fig. 8 for a brief description of a third embodiment of a valve according to the invention. The greater part of the components of the valve 56 in the third embodiment are similar to those of the first and the second embodiment, the notable difference being that venting of the volume trapped inside the valve piston rod at the end of the shank head 37 is vented by a valve stem conduit 57 in form of an axial bore through the valve piston rod rather than through a transverse bleed hole as was the case in the first and the second embodiment (reference 35 in fig. 1). Thus, the trapped volume is vented to the valve cylinder upper volume 25 communicated to the valve cylinder end port rather than to the valve chamber 28 as in the previous embodiments.

The reduced cross sectional area of the shank head 37 as compared to that of the valve piston 23 implies that the force applied onto the valve cone by the effect of a vacuum communicated to the valve cylinder end port 24 is comparatively small. Therefore, an overpressure in the valve discharge line may easily overcome the force due to the vacuum on top of the shank head 37 and thus allow the valve cone to stay in sealing engagement with the valve seat which is the situation illustrated in fig. 8. Not until the back-pressure on the valve cone has been reduced to a small value will the valve cone actually lift.

In the third embodiment, the lifting force applied on the cone depends on the pressure differential across the compressor and it is not as accurately controlled as is the case with the first or the second embodiment where the lifting force is provided by a cone lifting spring. On the other hand, the third embodiment has the advantage that the lifting spring may be omitted and the mechanical design thus simplified.

Reference is now made to fig. 3 showing a system diagram of a refrigeration system which may be operated according to the

method according to the invention. The refrigeration system 1 according to this figure comprises compressor 4, oil separator 7, discharge check valve 17, condenser 13, expansion valve 14, evaporator 15, and suction check valve 16. 5 These components are interconnected by fluid conduits 2 to build a closed loop in which refrigerant is contained and circulated. Obviously, the refrigeration system according to the invention may also include other components and modifications known in the art, e.g. additional check valves, shut-off valves, instrumentation etc. not shown in fig. 3. 10

In addition to this loop, the system illustrated in fig. 3 also incorporates a second loop for oil which essentially includes the compressor 4, the oil separator 7, the oil sump 15 8, the oil cooler 11, and the oil filter 12 from which oil is returned through oil return line 43 to the compressor 4.

The discharge check valve is provided with a fluid connection through pipe 3 through a shut-off valve A, ref. 41, to the 20 refrigerant conduit at a point between the suction check valve and the compressor inlet 5. This communication is by way of the shut-off valve A, ref. 41, which is open during normal operation. Another pipe 3 branches off to pass shut-off valve B, ref. 42, which is closed during normal operation 25 to be connected to a point of the conduit 2 adjacent the discharge check valve outlet 19.

The refrigerant used may comprise ammonia, R22, R134a, R404A, HFC, hydrocarbon refrigerants or other refrigerants as known 30 in the art.

In the preferred embodiment, ammonia is used for refrigerant and the compressor comprises a screw type compressor known in the art per se. As mentioned above, this type of compressor 35 needs to be fed with oil which becomes mixed with the refrigerant. The mixture of oil and refrigerant is taken to the oil separator from which oil is taken out through oil

discharge 9 while refrigerant is taken out through refrigerant discharge 10.

5 The screw compressor is capable of starting up and operating for some time without lubrication. In the system as illustrated in fig. 3 there is no oil pump in the oil loop, oil being circulated simply by the pressure built up at the oil discharge by the compressor itself. Build-up of the pressure is greatly accelerated by the discharge check valve shutting  
10 off extensive parts of the refrigerant loop until the discharge check valve decides that the pressure built up is sufficient, at which stage it will permit a gradual opening.

15 In the preferred embodiment opening of the discharge check valve is initiated at 2 Bars and the valve is fully opened at a pressure of about 2.5 Bars subject to the condition explained above, i.e. that there is no substantial back pressure across the valve. Therefore, in situations, e.g. with extended circuits where a substantial amount of refrigerant might have condensed in the conduit between discharge  
20 check valve and the condenser, thereby possibly building up a substantial pressure head at the discharge check valve outlet, the discharge check valve would stay closed until a higher pressure had been built up in the oil separator and would open only when the pressure in the oil separator would  
25 overcome the pressure at the valve outlet.

During normal service, the compressor will build up sufficient pressure to keep the discharge check valve fully opened,  
30 thus eliminating any pressure loss here. The pressure built up by the compressor may for instance attain a value in the range from 8 to 20 Bars.

35 If the power to the compressor is switched off, the pressure in the oil separator will cause the compressor to reverse its rotation until the pressure differential across the compressor has been eliminated. This will eliminate the lift on the

piston in the discharge check valve which will close by the positive force of the return spring which ensures a safe closure. The closing force may be increased by shutting off the shut-off valve A, ref. 41, and opening the shut-off valve B, ref. 42, as might be preferred on occasions when the compressor is not running. In many applications, the closing force provided by the return spring will, however, be sufficient also when the valve A is left open, and the system may be modified relative to the system of fig. 3 by deleting the branch line with the valve B.

Reference is now made to fig. 4 for an explanation of a second version of a refrigeration system 53 wherein a control valve according to a first embodiment of the invention may be used. The refrigeration system according to this figure is for a substantial portion identical to the refrigeration system according to fig. 3, the notable difference being that instead of suction check valve 16, a compressor discharge check valve 55 is installed on the conduit 2 between the compressor discharge 6 and the oil separator 7.

Common types of check valves generally cause some pressure drop in the throughflow state, e.g. in the order of 0.2 Bars. As a result the oil is subjected to an additional pressure drop implying that the pressure required to drive the oil around in the oil loop is higher relative to that of the system of fig. 3 by the pressure drop in the check valve. If this pressure drop is not insignificant it may easily be accounted for, in the valve according to the invention, by adjusting the threshold level setting of the discharge valve in order that the discharge check valve will only open when the pressure has risen to a level which is sufficient for this particular system.

With the system layout of fig. 4, the check valve 55 will not permit any backflow in the compressor while the power is shut off. The low pressure on the compressor suction side may



therefore be maintained and the control valve may not close immediately. Closure of the control valve may, however, be effected by closing shut-off valve A and opening shut-off valve B to allow the higher pressure at the valve outlet to be communicated to the upper volume of the valve cylinder.

Aside from this consideration, reference may be had to the explanation given above to the refrigeration system according to fig. 3.

Reference is now made to fig. 5 for a brief explanation of a third version of a refrigeration system 54 in which system a control valve according to the second embodiment of the invention is used. The system 54 according to fig. 5 has the check valve arranged similarly to the system 53 according to fig. 4. The system according to fig. 5 is distinguished mainly by featuring a valve 50 according to the second embodiment mentioned above, i.e. the embodiment with differential connections to the cylinder. The valve connections are arranged so that the valve cylinder end port is communicated by a pipe 3 to the refrigerant conduit adjacent the compressor inlet 5 while the valve cylinder side port 51 is connected by a section of pipe 3 to the refrigerant conduit 2 between the compressor discharge 6 and the check valve 16.

In this system, the pressure applied by the piston in the discharge check valve is effectively accurately controlled by the pressure differential across the compressor alone.

When the power to the compressor is switched off, the pressures in the upper and the lower volume of the valve cylinder may quickly equalize through the compressor and the control valve will close by the action of the return spring.

Although various components and systems have been explained in particular set-ups above, this is not to exclude that such components or systems might be applied in other set-ups or

might be configured differently. Although particular examples have been mentioned the detailed explanation has the sole purpose of facilitating understanding of the invention and is not intended to limit the scope thereof which is defined  
5 exclusively by the appended patent claims.

C l a i m s

1. A method of operating a refrigeration system wherein refrigerant and oil are fed to a compressor and compressed, the compressed mixture of refrigerant and oil is fed to an oil separator from where the refrigerant and the oil are discharged into respective separate discharge conduits, an oil discharge conduit communicating oil through an oil return line to be returned to the compressor, a refrigerant discharge conduit communicating refrigerant from the oil separator through a control valve to enter other parts of the refrigeration system which parts together with the components mentioned above form a closed circuit by which the refrigerant after compression is expanded and returned to the compressor, the control valve being connected by a control pipe to a point of the conduit adjacent the compressor inlet and being operated to control throughflow in order to maintain a predetermined threshold level of overpressure at a point of the fluid conduit in fluid communication with the compressor outlet relative to the pressure at the compressor inlet, to block flow provided the overpressure is below said threshold level or provided the pressure at the valve outlet exceeds that at the valve inlet and in order to open so as not to create any substantial pressure drop to throughflow, provided the pressure in the oil separator exceeds that in the valve discharge line and provided the level of overpressure substantially exceeds the threshold level, the predetermined threshold level of overpressure being selected to be sufficient for driving oil through the oil return line to feed the compressor but substantially below the pressure attained during normal service.

2. A method according to claim 1, wherein the control valve is operated to perform a check valve function with a positive closing force while the overpressure in the oil separator relative to the pressure at the compressor inlet is below the threshold level.

3. The method according to claim 1, wherein the control valve cone is biased to lift off from the valve seat provided the overpressure substantially exceeds the threshold level in order that in these conditions the valve cone may take either  
5 of two stable states, a first state in which the valve cone is held sealingly to the valve seat by the pressure in the valve discharge line exceeding that in the valve inlet by an amount sufficient to overcome the biasing force, and a second state in which the valve cone is lifted off the seat to be  
10 opened to flow in both directions.

4. The method according to claim 1, wherein the control valve is operated to take as the point in fluid connection with the compressor outlet a volume in fluid communication  
15 with the valve outlet.

5. A control valve comprising a valve housing defining a valve inlet, a valve outlet, a valve seat, and a valve cylinder, said valve further comprising a valve cone guided  
20 to be movable in order to selectively approach the valve seat whereby to control passage of fluid from the valve inlet to the valve outlet, a valve piston sealingly received in said cylinder to be slideable along an axis of the cylinder, a valve cylinder port, a valve piston rod connected with the  
25 valve piston, a valve return spring biasing said valve piston rod in a direction towards the valve seat, the valve cone and the valve piston rod being provided with mutually cooperating abutment surfaces by which said valve piston rod may, when allowed to move by the action of the valve return spring,  
30 force the valve cone towards sealing engagement with the valve seat, the valve cone and the valve piston rod being further provided with cone lifting means by which the valve piston rod may on displacement in the direction away from the valve seat apply a force biasing the valve cone in the direc-  
35 tion away from engagement with the valve seat.

6. The control valve according to claim 5, wherein the valve cone lifting means is adapted to be capable of applying a lifting force sufficient to ensure reliable lifting of the valve cone against forces due to adherence in the seat, friction and gravity for any orientation of the control valve.

7. The control valve according to claim 5, wherein the valve return spring is adapted to bias the valve piston rod and the valve cone towards engagement with the valve seat with a force sufficient to make the valve capable of maintaining on varying conditions of flow from the inlet to the outlet a predetermined pressure differential between the inlet and the outlet.

8. The control valve according to claim 5, wherein the valve cone is guided by sliding engagement with the piston rod which is in turn guided by a sliding engagement with the valve housing.

9. The control valve according to claim 5, wherein the piston and the cylinder are adapted to subject one side of the piston facing the valve seat to the pressure prevailing at the valve outlet and the opposite side of the piston to the pressure as communicated through the valve cylinder port.

10. The control valve according to claim 5, wherein the cylinder is provided with two ports permitting fluid communication to both sides of the piston.

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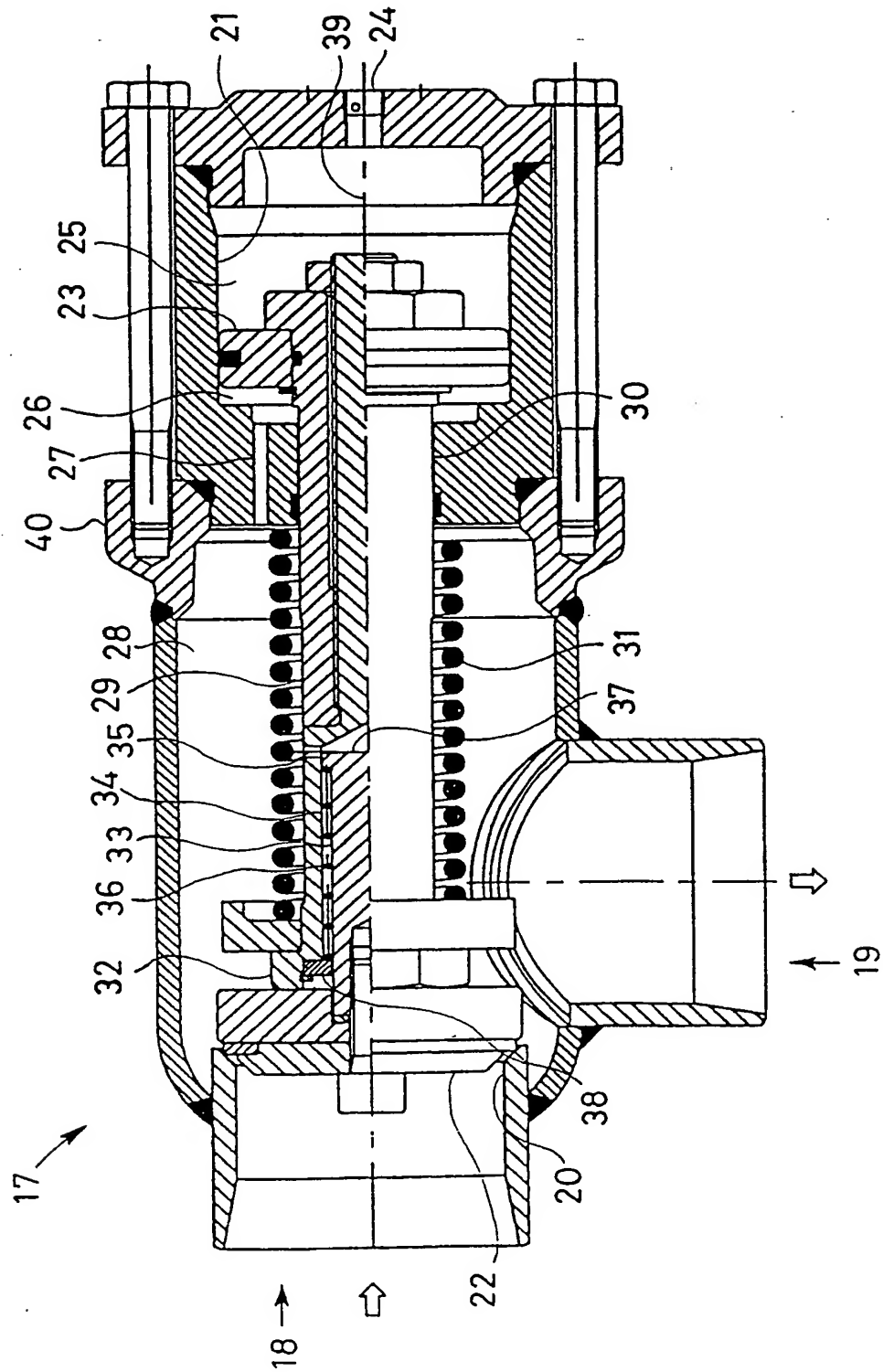


Fig. 1

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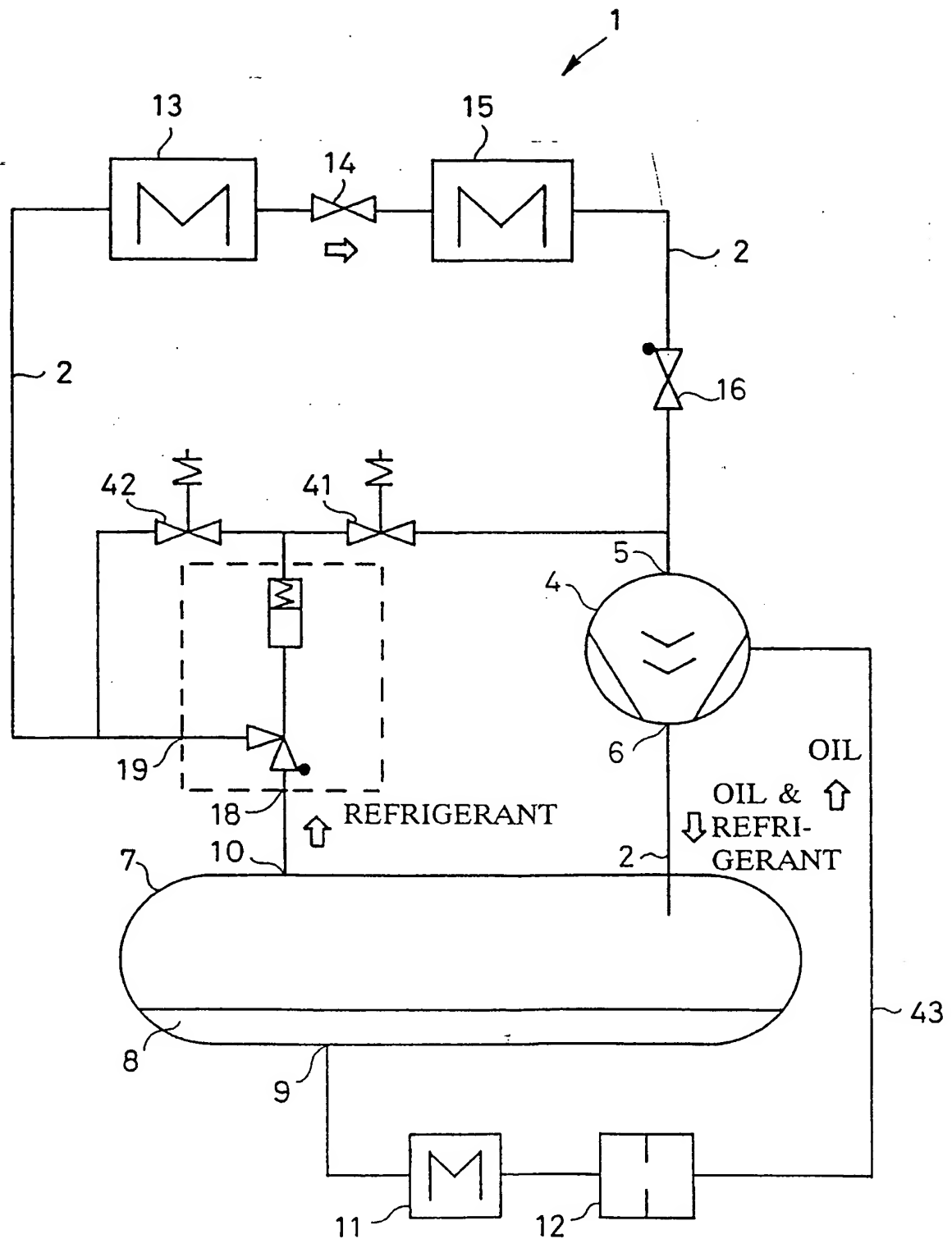


Fig. 3

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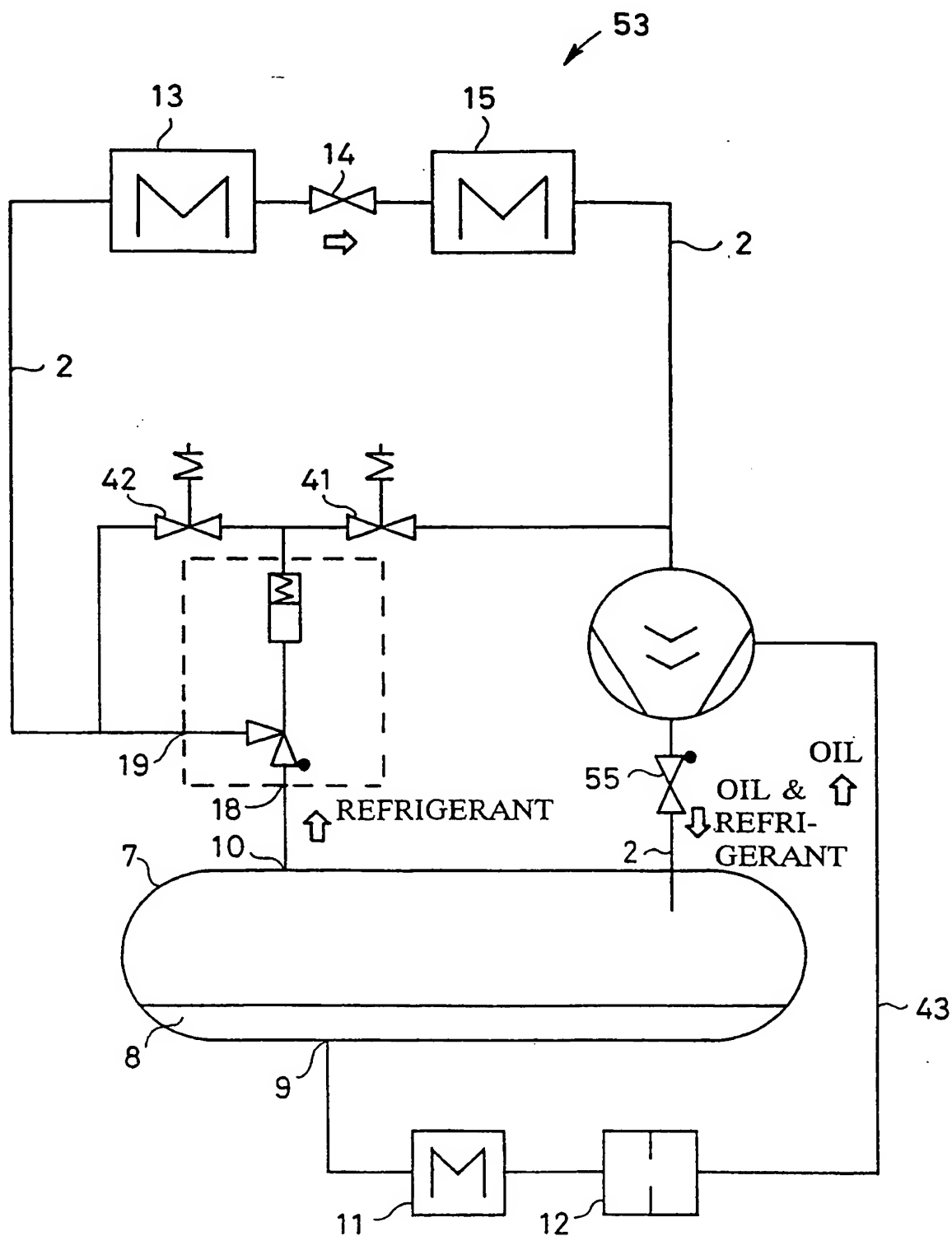


Fig. 4



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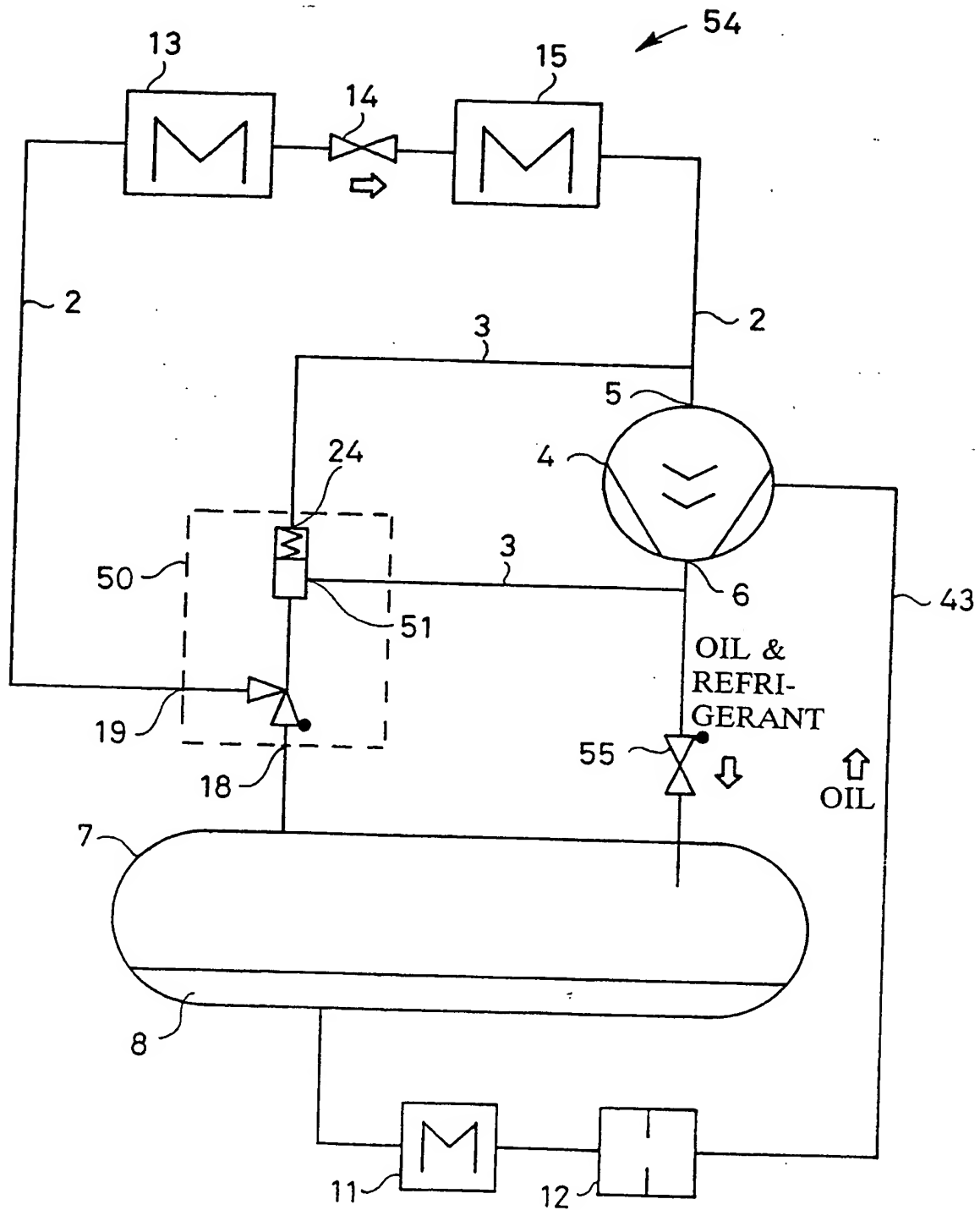


Fig. 5

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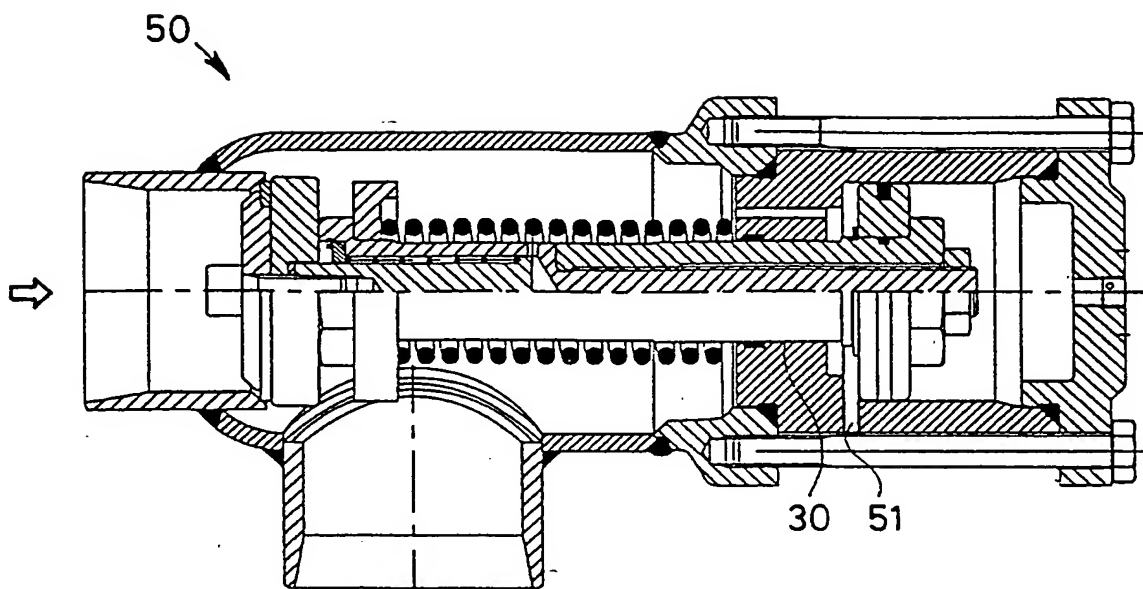


Fig. 2

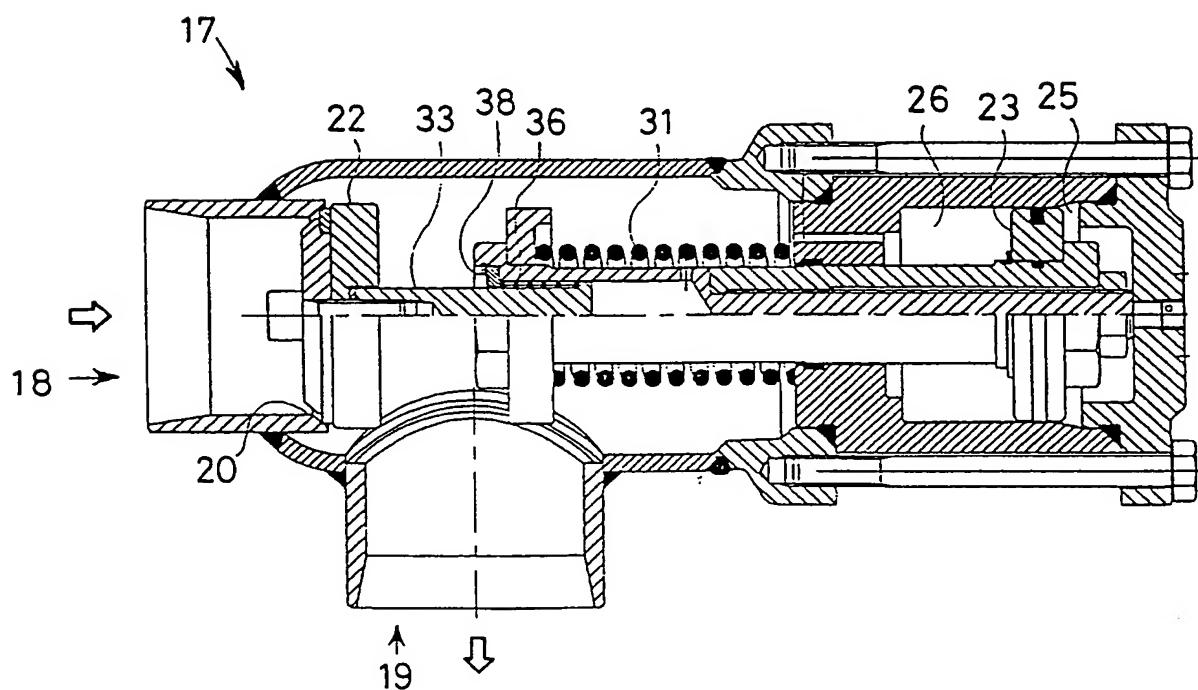


Fig. 6

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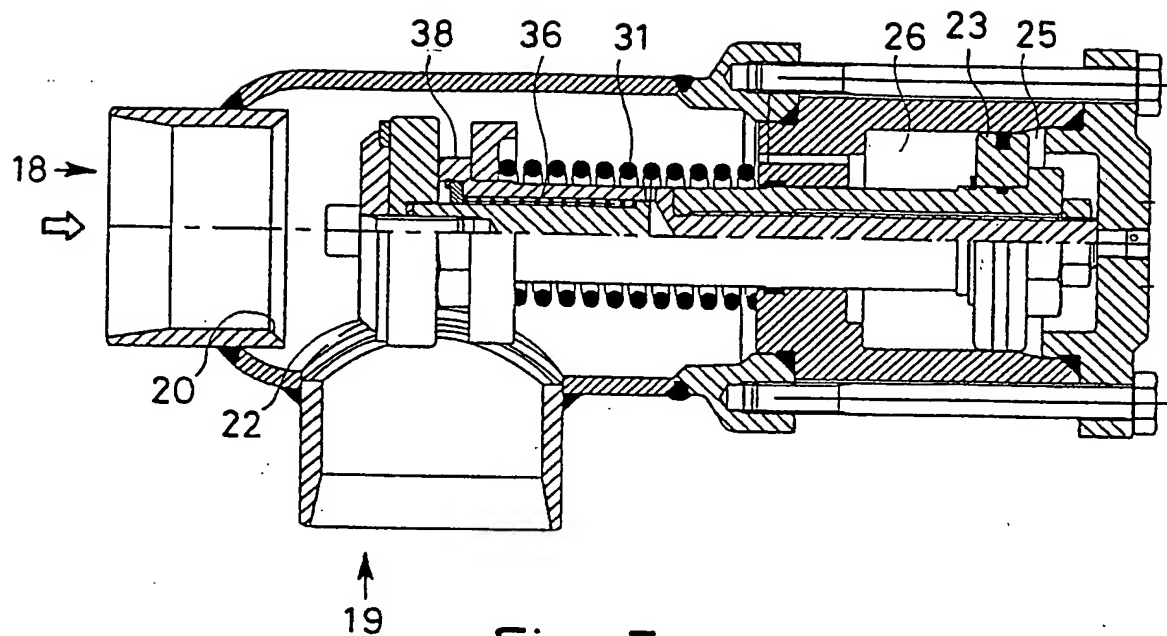


Fig. 7

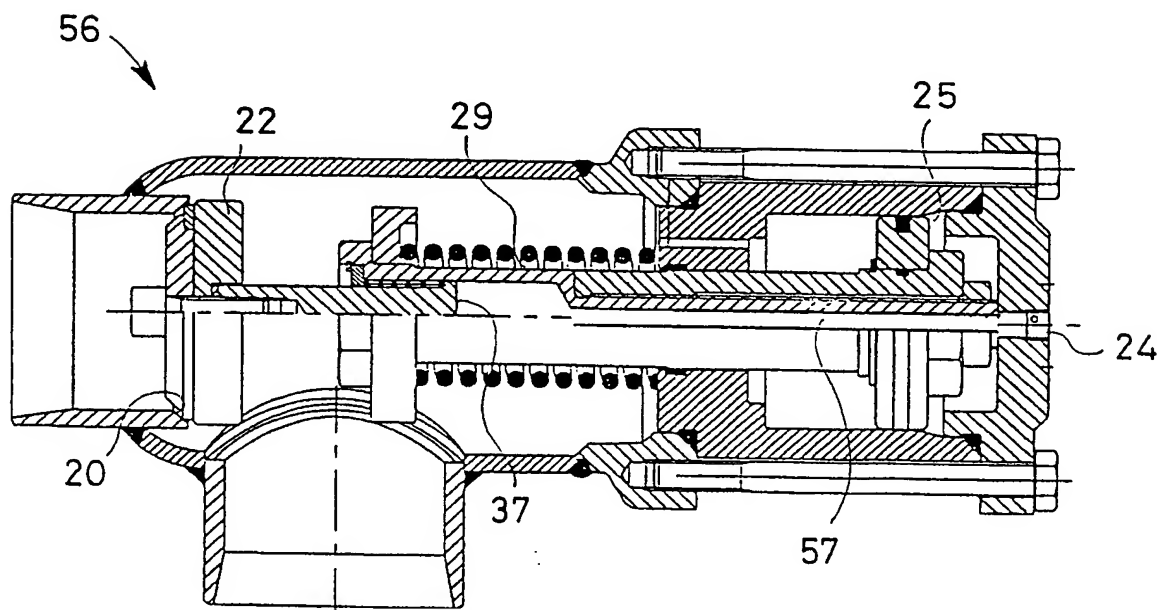


Fig. 8

# INTERNATIONAL SEARCH REPORT

International application No.

PCT/DK 96/00429

## A. CLASSIFICATION OF SUBJECT MATTER

IPC6: F25B 41/04, F16K 31/124  
According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: F25B, F16K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,N0 classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5134856 A (PILLIS ET AL), 4 August 1992 (04.08.92) --	1-5
A	WO 9114907 A1 (STAL REFRIGERATION AB), 3 October 1991 (03.10.91) --	1,2,5-7,9,10
A	GB 1202384 A (VEB MASCHINEN UND APPARATEBAU SCHKEUDITZ), 19 August 1970 (19.08.70) --	1-4
A	US 1994179 A (W. RAYMOND), 12 March 1935 (12.03.35) --	5-8

☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

<ul style="list-style-type: none"> <li>* Special categories of cited documents:</li> <li>"A" document defining the general state of the art which is not considered to be of particular relevance</li> <li>"E" earlier document but published on or after the international filing date</li> <li>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</li> <li>"O" document referring to an oral disclosure, use, exhibition or other means</li> <li>"P" document published prior to the international filing date but later than the priority date claimed</li> </ul>	<ul style="list-style-type: none"> <li>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</li> <li>"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</li> <li>"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</li> <li>"&amp;" document member of the same patent family</li> </ul>
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Date of the actual completion of the international search

15 May 1995

Date of mailing of the international search report

25 -05- 1997

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## INTERNATIONAL SEARCH REPORT

International application No.

PCT/DK 96/00429

## C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5123436 A (KOECHLEIN ET AL), 23 June 1992 (23.06.92)	8

**INTERNATIONAL SEARCH REPORT**  
Information on patent family members

02/04/97

International application No.  
PCT/DK 96/00429

Patent document cited in search report			Publication date	Patent family member(s)	Publication date
US	5134856	A	04/08/92	NONE	
WO	9114907	A1	03/10/91	AU 7584491 A EP 0551267 A SE 467708 B,C SE 9001104 A	21/10/91 21/07/93 31/08/92 28/09/91
GB	1202384	A	19/08/70	NONE	
US	1994179	A	12/03/35	NONE	
US	5123436	A	23/06/92	US 4998557 A	12/03/91